

CDS 130 Computing for Scientists

Final exam review

Topics:

MATLAB

1. Variables

- 1) Scalars, vectors, matrices, strings
- 2) Assignment

2. Create vectors : Row vector and Column vector

method 1: `A(5) = 1;`

method 2: `A = [2,3,4,5];` or `A=[2; 3; 4; 5];`

For row vectors, you can use either commas or spaces to separate the elements

method 3: `A = 2: -1: -6;` (colon notation).

If the increment is 1, the short-handed notation is `A = 2:5;` (i.e., `A=[2, 3, 4, 5]`)

method 4: form a new vector from previously defined vectors

```
>> A = [1, 2, 3];
```

```
>> B = [3, 4, 5];
```

```
>> C = [A, B]
```

method 5: iterations

```
>> A(1) = 0;
```

```
>> for I = 2:6
```

```
    A(I) = I
```

```
end
```

% this creates a new vector `[0, 2, 3, 4, 5, 6]`, and it does so by appending new pieces onto an existing vector, one piece at a time.

* Not tested: `linspace()`, `zeros()` and `ones()`.

3. Vectors in Matrix

- 1) row vector: `A(5)` means `A(1, 5)`
- 2) column vector `A(5,1)`
- 3) Transpose operator: `A(5)'` is now a column vector

4. Address vector elements

- 1) meaning of `A(1,5)` and `A(5)`
- 2) meaning of `A(5,1)`
- 3) `A(1:3)` is a new vector
- 4) `A(0.2)` is invalid

5. Vector operations

1) Vector added by a scalar

```
>> A = [1, 2, 3];
```

```
>> B = A + 3.0
```

```
B =
```

```
    4    5    6
```

3) Vector multiplied by a scalar

```
>> A = [1, 2, 3];
>> B = A* 3.0;
B =
    3    6    9
```

2) Add two vectors

```
>> A = [1, 2, 3]
>> B = [3, 4, 5]
>> C = A+B
C =
    4    6    8
```

4) Vector summation (sum of all vector elements)

```
>> C = [4, 6, 8];
>> sum(C)
ans = 20
```

5) Element-by-element operation (Attach . to the first vector) (extra credit)

```
>> C = A. * B
C =
    3    8   15

>> C = [1 1 1]. / A;
C =
    1   0.5  0.33333
```

6. Create Matrices

method 1: A(4,5) = 0.0;

method 2: A = [1, 2, 3; 3, 4, 5];

```
method 3: >> B = [1:4];
>> C = [4:7];
>> A = [B; C];
```

method 4: rand(10); % This creates a 10x10 matrix filled with random numbers [0,1]

7. Address matrix elements

(1) A(5, 4)

(2) A(1:2, 2,3)

(3) A(:, 2:3)

(4) A(: , :)

(5) A(2, :)

8. Matrix Operations

(1) matrix added by a scalar

```
>> A=[1, 2, 3; 3, 4, 5];
>> B = A + 2.0;
B =
    3    4    5
    5    6    7
```

(2) matrix multiplied by a scalar

- (3) matrix addition
(4) element-by-element operation (dot operator)

```
>> A = [1, 2, 3; 4, 5, 6];  
>> A.*A  
ans =  
     1     4     9  
    16    25    36
```

- (5) Sum of matrix
>> sum(A)

```
ans =  
    14    77
```

9. Iterations

- (1) syntax:

```
for i=1:10  
    do something  
end
```

Example 1:

```
A = [1:0.2:1.5; 0.5:-0.1: 0.3]  
for myVar = 0.2:0.5:1.3  
    A = A * myVar;  
end
```

Example 2:

Considering the following iteration code, what is A(12)?

```
A(9)=13;  
for i=[10:12] ;  
    A(i)=A(i-1)+37;  
end
```

10. Nested for-loops

```
for i=1:100  
    for j =i:100  
        do something  
    end  
end
```

Example (1): Using nested for-loops to create/modify matrix elements

```
11 12 13 14 15  
13 14 15 16 17  
15 16 17 18 19
```

Matlab code:

```
for i=1:3
    for j = 1:5
        A(i,j) = 8+i *2+j
    end
end
```

11. Plot

Steps to make a plot:

step 1: Guess the plot range, a, b. (-10, 10)

step 2: create x and y vectors. Use x as an independent variable, and use y as a dependent vector: $x = -10:0.01:10$

$y = x.^3 - 1$

(note: dot operators)

step 3: make a plot: `plot(x, y)`

Example: Is the following Matlab statement correct or not?

```
Plot([2,3,4, 5], [2,3,4,5]);
```

You can also plot multiple curves using `plot`.

12. Fill

Use 'fill' to generate polygons filled with colors.

`fill(x, y, 'k')`

Example:

```
x = [0, 0, 1, 1];
```

```
y = [1, 2, 2, 1];
```

```
c = [1, 0, 0];
```

```
fill(x, y, c);
```

%note: the coordinates of x and y must match. The sequence of the points are important.

13. Relational operators

(1) Six relational operators: $>$, $<$, $>=$, $<=$, $==$, $\sim=$

(2) Relational operators can be applied to vectors:

Example:

Given arrays $\mathbf{x} = [0 \ 7 \ 3 \ 5]$ and $\mathbf{y} = [2 \ 8 \ 7 \ 0]$, these are some possible relational operations:

Operation:

Result:

$k = \mathbf{x} < \mathbf{y}$ $k = [1 \ 1 \ 1 \ 0]$

$k = \mathbf{x} <= \mathbf{y}$ $k = [1 \ 1 \ 1 \ 0]$

$k = \mathbf{x} == \mathbf{y}$ $k = [0 \ 0 \ 0 \ 0]$

14. Logic operators

(1) Three logic operators: $\&$, $|$, \sim

(2) Logic operators can be applied to vectors or matrices.

Example:

Given arrays $\mathbf{x} = [0 \ 7 \ 3 \ 5]$ and $\mathbf{y} = [2 \ 8 \ 7 \ 0]$, these are some possible relational operations:

| Operation: | Result: |
|--|--------------------------------|
| $\mathbf{k} = \mathbf{x} \ \& \ \mathbf{y}$ | $\mathbf{k} = [0 \ 1 \ 1 \ 0]$ |
| $\mathbf{k} = \mathbf{x} \ \ \mathbf{y}$ | $\mathbf{k} = [1 \ 1 \ 1 \ 1]$ |
| $\mathbf{k} = \mathbf{x} \ \& \ \sim \mathbf{y}$ | $\mathbf{k} = [0 \ 0 \ 0 \ 1]$ |

Example:

$\mathbf{M} = [0.2, 0.3, 0.7; 0.6, 0.5, 0.5];$

$\sim(\mathbf{M} > 0.5)$

ans:

15. if-statements

Syntax:

```
if statement is true
    do something
elseif
    do anything else
else
    do something
end
```

Or:

```
if statement
    do something
end
```

Example: Write a Matlab code to find the number of matrix elements greater than a threshold value.

```
M = rand(100);
threshold = 0.25;
counter = 0;
for i=1:100
    for j = 1:100
        if M(i,j) > threshold
            counter = counter + 1;
        end
    end
end
```

16. Colors

RGB

CYMK

$[1, 1, 0]$; $[1, 0, 1]$; $[0 \ 1, \ 1]$, $[0, 0, 0]$

17. Matrices as images:

(1) Indexed images

(2) True-color images

18. How to create a image

- (1) Create a colormap matrix: (the dimension is n x 3, n colors with each color represented by r, g, b components in 0-1).
- (2) Create a matrix: `M=rand(50)`; Designate/alter matrix elements
- (3) `imagesc(M)` and/or `imagesc`

19. Numerical Integration

(a) integrate the area enclosed by an irregular shape in an image.

(1) use `imread` (syntax) to load the sample. e.g.,

```
M = imread('http://cds130.org/wiki/images/Area.jpg', 'jpg');
```

(2) Check the type and size of the image.

```
whos M
```

(3) If the image is with the true-color type, convert it to the indexed image.

```
new_M = rgb2ind(M, 2)
```

(note: the new matrix will only contain 0's and 1's. In other words, there are only two colors)

(4) Access the matrix, and identify the areas of interest. (Calculate the total number of 1's and 0's).

```
total_area = 0
black_area = 0
for i=0: length(new_M(:,1)) %alternatively you can use whos new_M to find the size
    for j=0: length(new_M(1, :))
        total_area = total_area + 1;
        if new_M(i,j) > 1
            black_area = black_area +1
        end
    end
end
end
fprintf('The fraction of the enclosed area is %f\n', black_area/total_area);
```

(b) Area underneath a curve.

$$f(x) = x \sin(x^2) + x^2 \quad (0.2 < x < 1.3)$$

Step 1: plot the curve to get a feel of the problem.

```
x = -10:0.01:10;
y = x.*sin(x.^2) + x.^2;
plot(x,y)
```

Step: 2: discretize the range of x

```
clear;
dx = 0.01;
```

```

xmin = 0.2;
xmax = 1.3;
imin = 1;
imax = (xmax-xmin)/dx + 1;
x = xmin:dx:xmax;
y = ...;
Step 3: integrate the area.

```

area=0 % this needs to be initialized before you can use it.

```

for i=1:imax
    area = area + y(i)*dx;
end

```

Step 4: print out the area that you have integrated.

```

display (area);

```

21. Population growth.

Mathematical model:

$$\frac{dP}{dt} = \alpha P$$

Computational model:

$$P(i+1) = P(i) + P(i) * \text{rate};$$

Note: the rate could be positive or negative. If rate > 0 (population growth), If rate < 0, population decay.

Question: Currently you have \$1000 in a bank account. If the monthly interest rate is 10%, 24 months later, how much will you have in the same account?

Step 1: initialization

```

rate = 0.1
% you decide to use a vector to register the amount of money in each year.
P(1) = 10000; % month 1.

```

Step 2: iteration

```

for i=1:24 % 24 months
    P(i+1) = P(i) * rate + P(i);
end

```

Step 3: plot to see P(i) as function of month.

```

plot ([1:25], P);
P(24)

```